

2017-05

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<http://hdl.handle.net/10026.1/9562>

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10.1016/j.healthplace.2017.03.008

Health & Place

Elsevier BV

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Natural environments and subjective wellbeing:

Different types of exposure are associated with different aspects of wellbeing

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### Abstract

Despite growing interest in the relationships between natural environments and subjective wellbeing (SWB), previous studies have various methodological and theoretical limitations. Focusing on urban/peri-urban residents ( $n = 7,272$ ) from a nationally representative survey of the English population, we explored the relationships between three types of exposure: i) 'neighbourhood exposure', ii) 'visit frequency', and iii) 'specific visit'; and four components of SWB: i) evaluative, ii) eudaimonic, iii) positive experiential and iv) negative experiential. Controlling for area and individual level socio-demographics and other aspects of SWB, visit frequency was associated with eudaimonic wellbeing and a specific visit with positive experiential wellbeing. People who visited nature regularly felt their lives were more worthwhile, and those who visited nature yesterday were happier. The magnitude of the association between weekly nature visits and eudaimonic wellbeing was similar to that between eudaimonic wellbeing and life circumstances such as marital status. Findings are relevant for policies to protect and promote public access to natural environments.

**Key Words:** Natural environments; Subjective wellbeing; Eudaimonic wellbeing; Monitor of Engagement with the Natural Environment; Exposure-response relationships.

## Natural environments and subjective wellbeing:

Different types of exposure are associated with different aspects of wellbeing

*“Our working landscapes, cultural sites, parks, coasts, wild lands, rivers, and streams are gifts that we have inherited from previous generations. They are the places that offer us refuge from daily demands, renew our spirits, and enhance our fondest memories...Today, however, we are losing touch with too many of these places.” Barack Obama (2010)*

### Introduction

In his second year of office, former US President Obama issued the Presidential Memorandum on America's Great Outdoors (2010). The aim was to remind American's of the benefits to health and wellbeing of natural outdoor spaces, and to warn people about the consequences of greater urbanisation and detachment from the kinds of spaces in which we evolved physically and culturally (United Nations, 2005). His concerns have been echoed around the world (e.g. UK Department for Environment, Food and Rural Affairs, 2011). Importantly, this interest coincided with a rapid increase in relevant scientific research, much of it demonstrating a positive relationship between natural environments and health and wellbeing in general (for reviews see: Bratman, Hamilton & Daly, 2012; Capaldi, Dopko & Zelenski, 2014; Gascon, Triguero-Mas, Martinez et al., 2015; Hartig, Mitchell, de Vries & Frumkin, 2014; Keniger, Gaston, Irvine & Fuller, 2013; McMahan & Estes, 2015; Sandifer, Sutton-Grier & Ward, 2015). Although encouraging, previous work on the relationships between natural environments and psychological aspects of wellbeing, in particular, has several methodological and theoretical limitations.

Methodologically, when exploring wellbeing outcomes, studies usually operationalise exposure to natural environments as either: a) 'neighbourhood exposure', i.e. the amount of green spaces such as parks/woodlands (de Vries, Verheij, Groenewegen, &

Spreeuwenberg, 2003; Gascon, et al., 2015) and blue spaces such as rivers/coast (de Vries, ten Have, van Dorsselaer et al., 2016; White, Wheeler, Alcock & Depledge, 2013a) in the area around one's home; or b) a single 'specific exposure' of limited duration (e.g. a park walk, Berman, Jonides, & Kaplan, 2008; McMahan & Estes, 2015; Nisbett & Zelensky, 2011). An assumption of the neighbourhood exposure approach is that, as well as possibly having a window view of nature (Nutsford, Pearson, Kingham, & Reitsma, 2016), people who live near natural environments will visit them more often for recreational purposes (e.g. Schipperijn, Ekholm, Stigsdotter et al., 2010). An assumption of the specific exposure approach tends to be that the positive effects of a single exposure speak to potential cumulative benefits from multiple exposures (e.g. Hartig et al., 2003, p.122). In other words, both approaches imply that a third type of exposure (beyond simply neighbourhood proximity or one-off visits), may be important for wellbeing, i.e. the frequency of exposure through voluntary visits (Shanahan, Fuller, Bush, Lin, & Gaston, 2015). We know of no previous research that has looked at the relationships between wellbeing outcomes and: i) neighbourhood exposure; ii) visit frequency; and iii) a specific visit; in the same analysis.

Theoretically, previous studies that have investigated the relationship between natural environments and wellbeing have tended to neglect certain aspects of subjective wellbeing (SWB, i.e. how individuals think and feel about their lives, Diener, Suh, Lucas & Smith, 1999). Specifically, building on long-standing philosophical debates, there is growing research and policy consensus (Kahneman, Diener & Schwarz, 1999; O'Donnell, Deaton, Durand, Halpern & Layard, 2014) that there are four components of SWB. These include: a) *Evaluative wellbeing*, how well individuals think their life is going overall; b) *Eudaimonic wellbeing*, how meaningful/worthwhile individuals think their behaviours/activities are; and c) *Positive* and d) *Negative hedonic or experiential wellbeing*, the emotions of pleasure (e.g. happiness) and pain (e.g. anxiety) individuals regularly experience. While the 'evaluative' component (e.g. life satisfaction) tends to be used in studies exploring the relationship with neighbourhood exposure, and the 'experiential' components in specific visit studies, very

little research has considered the ‘eudaimonic’ component. Of the few studies that have explored this dimension of SWB, the focus has been on specific aspects of eudaimonic wellbeing, such as feelings of vitality (Ryan, Weinstein, Bernstein, et al., 2010) and pro-social behaviours (Weinstein, Przybylski & Ryan, 2009), following single exposures. We know of no previous quantitative research that has looked at the relationship between natural environments and eudaimonic wellbeing in general, or how neighbourhood exposure and visit frequency may be associated with how meaningful/worthwhile individuals feel their lives to be.

Qualitative research in health geography does, however, provide some clues linking nature exposure and eudaimonic wellbeing from narratives elicited during in-depth interviews (e.g. Bell, Phoenix, Lovell, & Wheeler, 2015; Völker, & Kistemann, 2013). For instance, in one interview during a coastal visit, a participant in Bell et al.’s (2015) study says: *“I think after living in London so many years, you’re so enclosed. So to have that space and realise that there’s a bigger thing out there than you, and nature is quite an amazing thing, when you look at the sky and the sea and the birds, just to kind of (pause) take it in, and sometimes it’s like, well maybe my problems aren’t as bad as I perceive them to be... it kind of puts things into perspective”* (p.62). Typical of these interviews, this quote emphasises thought processes beyond experiential emotional states including broader considerations such as being mindful of the present, self-transcendence, and being able to put things in perspective, all facets of eudaimonic wellbeing more broadly (Ryan & Deci, 2001).

In short, the current research aimed to address several methodological and theoretical limitations in earlier work by simultaneously exploring multiple types of exposure, including regular voluntary nature contact, and multiple components of SWB, including eudaimonic wellbeing. It did this by using data from a large nationally representative survey, conducted via in-home interviews in England. Following the focus on urbanisation as a potential factor in detachment from nature, our analyses also focused on urban and peri-urban residents

(White, Wheeler, Alcock & Depledge, 2013b). Specifically we investigated the relationships between three types of natural environment exposure and four components of subjective wellbeing. Exposure was operationalised in terms of: a) 'neighbourhood nature' (% local area categorised as green/blue space); b) 'visit frequency' (frequency of recreational visits over the previous 12 months); and c) 'specific visits' (whether individuals visited nature 'yesterday'). SWB was operationalised using single item measures of the four components described above, as recommended by the Organisation for Economic Cooperation and Development (OECD, 2013): a) life satisfaction (evaluative), b) meaningful/worthwhile activities (eudaimonic), and c/d) happiness and anxiety yesterday (positive/negative experiential).

Based on earlier research we constructed three hypotheses. Of note, these involved controlling for the other aspects of SWB. Because the four measures are generally correlated, controlling for their covariance allows clearer conclusions to be drawn about which aspects of SWB are uniquely associated with which exposure types. First, we hypothesised that the evaluative component of SWB (life satisfaction) would be related to neighbourhood exposure, because it measures an individual's consideration of their overall circumstances (e.g. income and neighbourhood), rather than specific behaviours. Second, we hypothesised that the eudaimonic component of SWB (meaningful/worthwhile activities) would be positively related to visit frequency. If any given visit to nature is 'worthwhile', more frequent visits should be associated with greater overall feelings that one is living a meaningful/worthwhile life. Third, we hypothesised that the experiential components of SWB (happiness and anxiety yesterday) would be most strongly related to whether or not an individual made a specific visit to nature yesterday. Whether or not one lives near nature or visits regularly, unless one actually visited yesterday there was no reason to think that one's mood yesterday would be positively affected. As the data were from a large, representative UK survey, we were able to explore these relationships while controlling for potential

confounders including: neighbourhood factors (e.g. local crime statistics), individual socio-demographics (e.g. health) and time-related factors (e.g. weekend vs. weekday, season).

## Method

### *Participants*

Participants were drawn from the two waves of the Monitoring Engagement with the Natural Environment (MENE) survey that contained the SWB questions (Waves 4 and 6). The survey is part of the UK government's national statistics and sampling aims to ensure that respondents are representative of the adult English population (Natural England, 2011a). Each individual is assigned an urbanity code based on the Lower-layer Super Output Areas (LSOAs) in which they live. There are 32,482 LSOAs in England (2001 census) each containing approximately 1,500 people and having a mean area of 4km<sup>2</sup>. LSOAs are categorised as being either Urban (>10,000 inhabitants; 83.9% of the MENE sample), Peri-urban ('Town & Fringe', < 10,000; 8.2% of the MENE sample), or Rural ('Village, Hamlet, Isolated Dwelling'; 5.8% of the MENE sample). The LSOAs of 2.1% of the sample were missing. Following previous research into green/blue space in England (e.g. White, et al., 2013b) we restricted our analyses to urban/peri-urban dwellers (92.1%) to avoid confounding levels of green space with the urban-rural distinction; the mean % of greenspace in urban, peri-urban, and rural areas is 32.5%, 67.1% and 91.2% respectively. Including rural dwellers did not alter any of the effects reported below. In sum, the final sample was  $n = 7,272$ , and can be considered representative of England's Urban/Peri-Urban population.

### *Procedure*

The MENE is commissioned by Natural England, a part of the UK's Department for the Environment Food and Rural Affairs (DEFRA). It is part of a face-to-face in-home omnibus survey conducted across the whole of England and throughout the year to reduce potential geographical and seasonal biases (Natural England, 2011a). Although approximately 800 individuals are interviewed every week, the SWB questions were only asked in Waves 4 and 6 and the eudaimonic and experiential questions were not collected equally across the year



resulting in reduced data for Spring and Summer months. Trained interviewers follow a computer assisted interview script and recording protocol (Natural England, 2011b).

### *Subjective wellbeing*

The four SWB questions were developed by the UK's Office of National Statistics (ONS, 2011): 1) '*Overall how satisfied are you with life nowadays?*' (Evaluative); 2) '*Overall to what extent do you feel that the things you do in your life are worthwhile?*' (Eudaimonic); 3) '*Overall, how happy did you feel yesterday?*' (Positive experiential); and 4) '*Overall how anxious did you feel yesterday?*' (Negative experiential). Responses ranged from 0 'Not at all' to 10 'Completely'. Given large skews in the distribution of all four measures, they were dichotomised around the median for present purposes. Specifically, scores of 8-10 on the first three items reflected 'High' (vs. 'Low') wellbeing (and included 56%, 58% and 58% of the sample respectively), and scores of 0-1 on the final item reflected 'Low' anxiety (and thus 'High' wellbeing, and included 52% of the sample). Our main analyses thus explored the Odds that individuals would report 'High' vs. 'Low' SWB as a function of different types of nature exposure. Analyses using the whole scale, and Ordinary Least Squares regressions, produced similar results (available on request).

### *Exposure*

'*Neighbourhood exposure*' was based on information about the LSOAs in which individuals lived, and was added by the authors to the MENE dataset from other sources. The land use mix (e.g. buildings, roads, gardens) within each LSOA (at the resolution of 10m<sup>2</sup>) was derived from the Generalised Land Use Database (Office of the Deputy Prime Minister, 2005). Following earlier studies we defined 'green space' as the land cover of 'green space' and 'domestic gardens' combined since one's own and other people's gardens could also provide visual benefits for wellbeing (White, et al., 2013b). Neighbourhood greenspace was divided into quintiles, with the lowest quintile used as the *reference category*. Since living near the coast has been found to be positively associated with higher SWB (Brereton, et al.,

2008), coastal proximity was included and based on the distance to the nearest coast of the population weighted centroid of the relevant LSOA (Wheeler, White, Stahl-Timmins & Depledge, 2012). For present purposes distance was dichotomised into near (<20km, [<12 miles]) vs. far ( $\geq 20$  km) from the coast (based on a threshold seen in Wheeler et al. 2012).

The second type of exposure, '*Visit frequency*', was measured using the item, "*Thinking about the last 12 months, how often, on average, have you spent your leisure time out of doors, away from your home? By out of doors we mean open spaces in and around towns and cities, the coast and the countryside. This could be anything from a few minutes to all day. It may include time spent close to your home, further afield or while on holiday in England. However this does not include routine shopping trips or time spent in your own garden.*" (Natural England, 2011b p.35). Response options were: 1) More than once per day; 2) Every day; 3) Several times a week; 4) Once a week; 5) Once or twice a month; 6) Once every 2-3 months; 7) Once or twice and 8) Never (= *reference*). To make the sample size in each category similar, we collapsed the first two options into 'Every day' and options 6 and 7 into 'A few times a year'.

The final type of exposure, '*Specific visit*', was based on whether respondents reported visiting any natural environment yesterday (Yes, or No = *reference*). Initial analyses suggested insufficient power to differentiate between visit locations (e.g. park vs. woodlands vs. coast).

### *Control variables*

SWB is associated with variables at both the area level (e.g. crime) and individual level (e.g. socio-economic status; Dolan, Peasgood & White, 2008), as well as temporal factors such as day of the week (e.g. weekend vs. weekday) and season (McKerron & Mourato, 2013). As these variables may also be related to nature exposure, we controlled for them using

available data in the MENE survey. Due to the categorical nature of control variables, dummy variables were constructed.

#### *Area level controls*

The LSOAs were used to derive Government Office Region (e.g. North East; London = *reference*) and local area level socio-economic status. Specifically, 'deprivation scores', were included based on factors such as local area crime rates, with data imported from the 2004 English Indices of Deprivation (Department of Communities and Local Government, 2008). Quintiles of Index of Multiple Deprivation (IMD) scores were derived from highest deprivation  $M = 22.57$  ( $SD = 1.41$ ), to lowest deprivation  $M = 6.63$  ( $SD = 1.08 = \textit{reference}$ ).

#### *Individual level controls*

Controls included: gender (male = *reference*), age (16-34 years = *reference*, 35-64 years,  $\geq 65$  years), occupational social grade (AB, C1, C2, DE = *reference*) as a proxy for socio-economic status (SES) with AB being the highest status social grade, employment status (full-time, part-time, in education, not working, retired, unemployed/not working = *reference*), marital status (married/cohabiting vs. single/separated/divorced/widowed = *reference*), children in the household ( $\geq 1$  vs. 0 = *reference*), ethnicity (White British vs. other = *reference*), long standing work/mobility limiting health issue (No vs. Yes = *reference*) and dog ownership (Yes vs. No = *reference*).

#### *Time-related controls*

The MENE records the date of the interview enabling us to establish the day of the week the interview took place, and the day of the week 'yesterday'. The interview day, categorised as either a Weekday (= *reference*) or a Weekend day, was used in the models to predict responses to the Evaluative and Eudaimonic questions. The day of the week yesterday, using the same dichotomy, was used to predict responses to the experiential questions, which also focused on 'yesterday'. Season was derived from the interview date and

categorised as either Spring, Summer, Autumn or Winter = *reference*. As the data were extracted from two waves, we also controlled for survey year (2014-2015 vs. 2012-2013 = *reference*).

### *Subjective wellbeing controls*

The final models for each component of SWB also controlled for the other three SWB components, using the binary versions described above. This allowed us to explore the unique relationships between each nature exposure type and each SWB component.

### *Analysis strategy*

We ran a series of models for each component of SWB. Due to space constraints, only two sets are presented below, with a further two sets presented in Tables S2-S5 in the online Supplementary Materials. The first set presented below were the unadjusted models exploring the simple relationships between neighbourhood exposure, visit frequency and specific visit and each SWB component. The second set were the fully adjusted models controlling for area, individual and time-related factors as well as the other three SWB components. The additional models in the Supplementary Materials explored: a) the relationships between SWB and neighbourhood exposure, without controlling for visit frequency and specific visit; and b) all exposure and SWB components, controlling for area, individual and time-related factors but not the other SWB components. These were conducted to explore potential mediating relationships; however, little evidence of mediation was found and a more detailed consideration of these issues is beyond the scope of the current paper. As all SWB variables were dichotomised into high vs. low, we used binary logistic regression models to predict the relative Odds that an individual would have High wellbeing, as a function of the different nature exposures and control variables.

## Results

### *Preliminary results*

As expected, initial analysis revealed moderate correlations between the four SWB questions. Evaluative wellbeing was correlated positively with both eudaimonic wellbeing and positive experiential wellbeing,  $r(7,272) = .56$  &  $r(7,265) = .47$ ,  $ps < 0.001$ , and negatively with negative experiential wellbeing  $r(7,272) = -.27$ ,  $p < 0.001$ . Eudaimonic wellbeing was also correlated positively with positive experiential wellbeing  $r(7,265) = .43$ ,  $p < 0.001$  and negatively with negative experiential wellbeing  $r(7,272) = -.23$ ,  $p < 0.001$ . Finally, positive and negative experiential wellbeing were also negatively correlated  $r(7,265) = -.34$ ,  $p < 0.001$ . Since only a moderate proportion of the variance between measures was shared (min  $r^2_{\text{eudaimonic/negative experiential}} = .05$ ; max  $r^2_{\text{evaluative/eudaimonic}} = .31$ ), we could conclude that the four items were not measuring the same underlying construct and thus examining the four components separately was appropriate. Nevertheless the moderate correlations still warranted the additional analyses, controlling for the other SWB measures, in order to better understand the unique contribution of exposure type on each aspect of SWB separately.

Descriptive data on environmental exposure for each SWB question is presented in Table 1. In terms of neighbourhood exposure, relatively few people (8.4%) lived in neighbourhoods with the top quintile of green space coverage ( $M = 86\%$ ), while approximately equal percentages (21-25%) lived in neighbourhoods with the lower four quintiles of green space coverage. Approximately 1/3<sup>rd</sup> lived within 20km of the coast. In terms of visit frequency, 10.5% visited natural environments every day, 20.4% visited approximately once a week and 10.8% reported never visiting natural environments. Finally, in terms of specific visits, only 7.7% reported a visit to nature yesterday. The  $N$ s and percentages in each category of SWB (High vs. Low) for each exposure category are also presented in Table 1. Similar details on all control variables are presented in Table S1.

*Table 1:* The frequency of individuals with each kind of nature exposure reporting Low vs. High wellbeing on all four components of subjective wellbeing.

		Evaluative wellbeing		Eudaimonic wellbeing		Experiential wellbeing			
	N <sup>a</sup>	Life satisfaction		Worthwhile activities		Happy (Positive)		Anxious (Negative)	
	(7,272)	Low	High	Low	High	Low	High	Low	High
		(1-7)	(8-10)	(1-7)	(8-10)	(1-7)	(8-10)	(1-2)	(3-10)
Neighbourhood green space <sup>b</sup>									
1 <sup>st</sup> quintile (Highest)	612	237	375	218	394	238	373	320	292
(M = 86.39%)	(8.4%)	(38.7%)	(61.3%)	(35.6%)	(64.4%)	(39.0%)	(61.0%)	(52.3%)	(47.4%)
2 <sup>nd</sup> quintile	1,578	720	858	642	936	669	906	758	820
(M = 60.97%)	(21.7%)	(45.6%)	(54.4%)	(40.7%)	(59.3%)	(42.5%)	(57.5%)	(48.0%)	(52.0%)
3 <sup>rd</sup> quintile	1,659	760	899	718	941	713	945	786	873
(M = 35.88%)	(22.8%)	(45.8%)	(54.2%)	(43.3%)	(56.7%)	(43.0%)	(57.0%)	(47.4%)	(52.6%)

<i>4<sup>th</sup> quintile</i>	1,871	881	990	798	1,073	807	1,063	874	997
<i>(M = 20.09%)</i>	<i>(25.7%)</i>	<i>(47.1%)</i>	<i>(52.9%)</i>	<i>(42.7%)</i>	<i>(57.3%)</i>	<i>(43.2%)</i>	<i>(56.8%)</i>	<i>(46.7%)</i>	<i>(53.3%)</i>
<i>5<sup>th</sup> quintile (Lowest)</i>	1,552	736	816	713	839	658	893	705	847
<i>(M = 7.21%)</i>	<i>(21.3%)</i>	<i>(47.4%)</i>	<i>(52.6%)</i>	<i>(45.9%)</i>	<i>(54.1%)</i>	<i>(42.2%)</i>	<i>(57.6%)</i>	<i>(45.4%)</i>	<i>(54.6%)</i>
Coastal proximity <sup>b</sup>									
<i>Near (&lt;20km)</i>	2,394	1,051	1,343	985	1,409	999	2,785	1,199	1,195
	<i>(32.9%)</i>	<i>(43.9%)</i>	<i>(56.1%)</i>	<i>(41.1%)</i>	<i>(58.9%)</i>	<i>(42.8%)</i>	<i>(57.2%)</i>	<i>(50.1%)</i>	<i>(49.9%)</i>
<i>Far (≥20km)</i>	4,878	2,283	2,595	2,104	2,774	2,086	2,785	2,244	2,634
	<i>(67.1%)</i>	<i>(46.8%)</i>	<i>(53.2%)</i>	<i>(43.19%)</i>	<i>(56.9%)</i>	<i>(42.8%)</i>	<i>(57.2%)</i>	<i>(46.0%)</i>	<i>(54.0%)</i>
Visits frequency (last 12 months) <sup>b</sup>									
<i>Every day</i>	763	299	464	243	520	283	480	380	383
	<i>(10.5%)</i>	<i>(39.2%)</i>	<i>(60.8%)</i>	<i>(31.8%)</i>	<i>(68.2%)</i>	<i>(37.1%)</i>	<i>(62.9%)</i>	<i>(49.8%)</i>	<i>(50.2%)</i>

<i>Several times a week</i>	1,734	704	1,030	643	1,091	657	1,074	885	849
	(23.8%)	(40.6%)	(59.4%)	(37.1%)	(62.9%)	(38.0%)	(62.0%)	(51.0%)	(49.0%)
<i>Once a week</i>	1,484	645	839	611	873	608	876	727	757
	(20.4%)	(43.5%)	(56.5%)	(41.2%)	(58.8%)	(41.0%)	(59.0%)	(49.0%)	(51.0%)
<i>Once/twice a month</i>	1,361	653	708	604	757	605	753	622	739
	(18.7%)	(48.0%)	(52.0%)	(44.4%)	(55.6%)	(44.6%)	(55.4%)	(45.7%)	(54.3%)
<i>Few times a year</i>	1,147	605	542	560	587	536	611	495	652
	(15.8%)	(52.7%)	(47.3%)	(48.8%)	(51.2%)	(46.7%)	(53.3%)	(43.2%)	(56.8%)
<i>Never</i>	783	428	355	428	355	396	386	334	449
	(10.8%)	(54.7%)	(45.3%)	(54.7%)	(45.3%)	(50.6%)	(49.4%)	(42.7%)	(57.3%)
Specific visit (yesterday) <sup>b</sup>									
<i>Yes</i>	559	231	209	175	384	289	270	323	299
	(7.7%)	(41.3%)	(37.4%)	(31.3%)	(68.7%)	(51.7%)	(48.3%)	(51.9%)	(48.1%)



<i>No</i>	6,713	3,103	2,880	3,833	2,910	3,154	3,559	3,450	3,831
	(92.3%)	(46.2%)	(42.9%)	(57.1%)	(43.4%)	(47.0%)	(53.0%)	(47.4%)	(52.6%)

Note: <sup>a</sup> First column percentages relate to total sample (i.e. % of 7,272); <sup>b</sup> All other percentages relate to % within each exposure category for each SWB outcome. See Table S1 in the Supplementary Materials for descriptives of Government Office Region, area level deprivation (IMD Scores), age, gender, socioeconomic status, employment status, marital status, children in household, illness/disability, ethnicity, dog ownership and time-related day of the week, season and survey wave.

*Main findings**Unadjusted models*

Unadjusted models provided support for all three hypotheses (Table 2). Evaluative wellbeing was positively related to neighbourhood exposure, with urban residents in the greenest quintile 1.3 times more likely to report high life satisfaction than residents in the least green quintile. Eudaimonic wellbeing was positively related to visit frequency, with individuals who visited everyday being nearly 2.5 times more likely to report that things they did in their life were highly worthwhile than those who never visited nature. Moreover, there was a noticeable exposure-response relationship; the Odds of reporting high levels of self-reported eudaimonic wellbeing increased with each increase in nature visit frequency. Finally, positive experiential wellbeing was positively related to a specific visit, with individuals who visited nature yesterday 1.5 times more likely to report high levels of happiness yesterday than individuals who had not visited nature. There were also some unexpected findings. Evaluative and experiential wellbeing were also related to visit frequency, in an apparent exposure-response fashion; and negative experiential wellbeing was unrelated to visiting nature yesterday.

Table 2: Unadjusted binary logistic regressions predicting high levels of four components of subjective wellbeing from neighbourhood exposure, visit frequency and specific visits to natural environments.

	Evaluative wellbeing		Eudaimonic wellbeing		Experiential (+)		Experiential (-)	
	(Life satisfaction)		(Worthwhile activities)		(Happiness yesterday)		(Anxiety yesterday)	
	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
Neighbourhood exposure								
Green space								
1 <sup>st</sup> quintile (Highest)	1.33**	(1.10, 1.62)	1.43***	(1.17, 1.74)	1.10	(0.90, 1.33)	0.80*	(0.90, 0.96)
2 <sup>nd</sup> quintile	1.02	(0.89, 1.18)	1.17*	(1.02, 1.35)	0.96	(0.84, 1.11)	0.93	(0.81, 1.07)
3 <sup>rd</sup> quintile	1.05	(0.91, 1.20)	1.09	(0.95, 1.26)	0.97	(0.84, 1.11)	0.94	(0.82, 1.09)
4 <sup>th</sup> quintile	1.00	(0.87, 1.14)	1.13	(0.99, 1.30)	0.97	(0.84, 1.11)	0.96	(0.84, 1.10)
5 <sup>th</sup> quintile (Lowest)	-	-	-	-	-	-	-	-
Coastal proximity								
<20km	1.06	(0.96, 1.17)	1.02	(0.92, 1.12)	1.00	(0.91, 1.11)	0.88*	(0.80, 0.97)
≥ 20 km (ref)	-	-	-	-	-	-	-	-
Visit frequency (last 12 months)								

<i>Every day</i>	1.81***	(1.48, 2.22)	2.49***	(2.02, 3.07)	1.63***	(1.33, 2.01)	0.79*	(0.64, 0.97)
<i>Several times a week</i>	1.74***	(1.46, 2.07)	2.01***	(1.69, 2.39)	1.60***	(1.35, 1.90)	0.74**	(0.62, 0.88)
<i>Once a week</i>	1.55***	(1.30, 1.85)	1.70***	(1.42, 2.02)	1.44***	(1.20, 1.71)	0.79**	(0.66, 0.94)
<i>Once/twice a month</i>	1.30**	(1.09, 1.56)	1.50**	(1.26, 1.79)	1.26*	(1.06, 1.51)	0.89	(0.75, 1.07)
<i>Few times a year</i>	1.09	(0.90, 1.30)	1.27	(1.05, 1.52)	1.17	(0.97, 1.40)	0.98	(0.81, 1.17)
<i>Never (ref)</i>	-	-	-	-	-	-	-	-
Specific visit (yesterday)								
<i>Yes</i>	1.04	(0.87, 1.24)	1.04	(0.87, 1.25)	1.50***	(1.24, 1.81)	0.91	(0.76, 1.08)
<i>No (ref)</i>	-	-	-	-	-	-	-	-
Controls <sup>a</sup>								
<i>Area level</i>	NO		NO		NO		NO	
<i>Individual level</i>	NO		NO		NO		NO	
<i>Time-related</i>	NO		NO		NO		NO	
<i>Other wellbeing</i>	NO		NO		NO		NO	
Constant	0.80		0.87		0.99		1.47	

Nagelkerke R <sup>2</sup>	0.02	0.03	0.01	0.01
N	7,265	7,265	7,265	7,265

Note: OR = Odds Ratios; CIs = Confidence Intervals; \*\*\* p<0.001; \*\* p<0.01; \* p<0.05

*Adjusted models*

These findings were qualified once all covariates were added in the fully-adjusted models (Table 3). Continuing to supporting hypotheses 2 and 3, the relationships between visit frequency and eudaimonic wellbeing and a specific visit and positive experiential wellbeing remained significant, even in the fully adjusted models. Even after all area, individual and time-related controls, as well as other components of SWB, were accounted for, individuals who visited natural environments daily were almost twice as likely (1.96) to report high levels of eudaimonic wellbeing than those who never visited, and those who did vs. did not visit nature yesterday were 1.7 times more likely to report high levels of happiness yesterday. That visit frequency was related to all four SWB outcomes in the unadjusted models but only to eudaimonic wellbeing in the adjusted models suggests that it was the covariance between eudaimonic wellbeing and the other three components of SWB that was accounting for these results in the unadjusted models.

*Table 3: Fully-adjusted binary logistic regressions predicting high levels of four components of subjective wellbeing from neighbourhood exposure, visit frequency and specific visits to natural environments.*

	Evaluative wellbeing		Eudaimonic wellbeing		Experiential (+)		Experiential (-)	
	(Life satisfaction)		(Worthwhile activities)		(Happiness yesterday)		(Anxiety yesterday)	
	OR	95% CIs	OR	95% CIs	OR	95% CIs	OR	95% CIs
<b>Neighbourhood exposure</b>								
Green space								
<i>1st quintile (Highest)</i>	1.03	(0.79, 1.33)	1.19	(0.92, 1.54)	0.87	(0.68, 1.11)	1.01	(0.81, 1.26)
<i>2<sup>nd</sup> quintile</i>	0.86	(0.71, 1.05)	1.18	(0.97, 1.43)	0.91	(0.76, 1.09)	1.04	(0.89, 1.23)
<i>3<sup>rd</sup> quintile</i>	0.94	(0.78, 1.13)	1.07	(0.89, 1.29)	0.92	(0.77, 1.10)	1.01	(0.87, 1.19)
<i>4<sup>th</sup> quintile</i>	0.89	(0.74, 1.06)	1.20*	(1.01, 1.43)	0.92	(0.78, 1.09)	1.01	(0.87, 1.17)
<i>5<sup>th</sup> quintile (Lowest)</i>	-	-	-	-	-	-	-	-
Coastal proximity								
<i>&lt;20km</i>	1.04	(0.89, 1.21)	0.93	(0.80, 1.09)	1.00	(0.87, 1.16)	0.96	(0.85, 1.09)
<i>≥ 20 km (ref)</i>	-	-	-	-	-	-	-	-
Visit frequency (last 12 months)								

<i>Every day</i>	1.06	(0.80, 1.39)	1.96***	(1.49, 2.58)	1.08	(0.83, 1.40)	1.16	(0.92, 1.46)
<i>Several times a week</i>	1.06	(0.84, 1.33)	1.57***	(1.25, 1.97)	1.14	(0.92, 1.42)	1.01	(0.83, 1.23)
<i>Once a week</i>	1.05	(0.83, 1.33)	1.33*	(1.06, 1.67)	1.08	(0.87, 1.34)	0.99	(0.82, 1.21)
<i>Once/twice a month</i>	0.96	(0.76, 1.22)	1.35*	(1.07, 1.69)	1.04	(0.83, 1.29)	1.04	(0.85, 1.26)
<i>Few times a year</i>	0.87	(0.68, 1.10)	1.26	(1.00, 1.58)	1.10	(0.88, 1.38)	1.07	(0.87, 1.31)
<i>Never (ref)</i>	-	-	-	-	-	-	-	-
Specific visit (yesterday)								
<i>Yes</i>	0.86	(0.69, 1.09)	0.89	(0.71, 1.12)	1.66***	(1.32, 2.08)	1.02	(0.84, 1.23)
<i>No (ref)</i>								
Controls <sup>a</sup>								
<i>Area level</i>	YES		YES		YES		YES	
<i>Individual level</i>	YES		YES		YES		YES	
<i>Time-related</i>	YES		YES		YES		YES	
<i>Other wellbeing</i>	YES		YES		YES		YES	
Constant	0.09		0.11		0.39		5.00	
Nagelkerke R <sup>2</sup>	0.48		0.44		0.48		0.19	
N	7,265		7,265		7,265		7,265	



Note: OR = Odds Ratios; CIs = Confidence Intervals; \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$  \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$ . Controls included in these fully adjusted models: Area level – government office region, deprivation (IMD scores); Individual level - age, gender, socioeconomic status, employment status, marital status, children in household, illness/disability, ethnicity, dog ownership; Time-related – year, season, day of the week ‘today’ or ‘yesterday’; Other wellbeing – evaluative, eudaimonic, positive and negative experiential (See Tables S2-5 for full details).

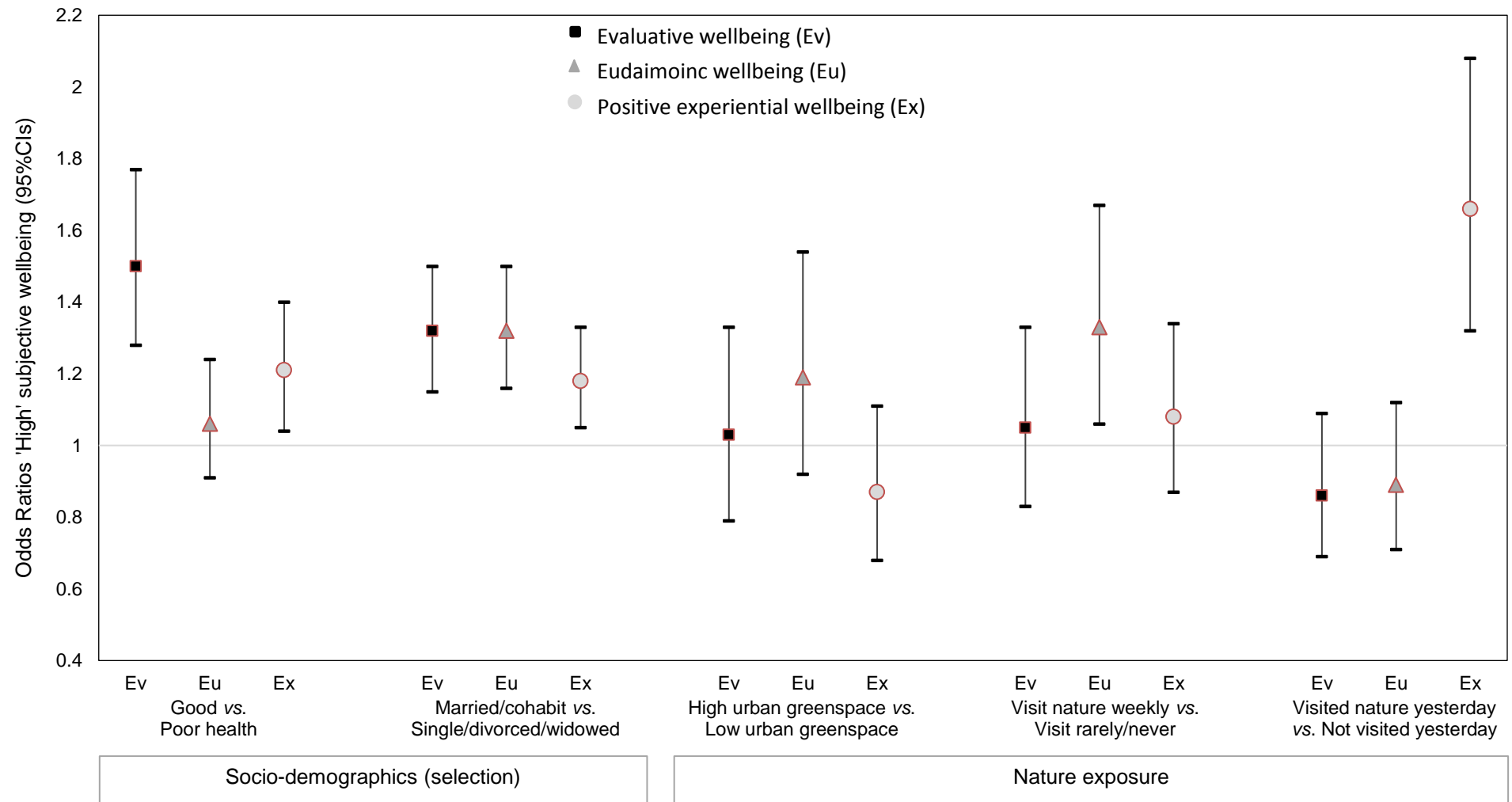
Contrary to hypothesis 1, however, there were no significant relationships between evaluative wellbeing and any of the three nature exposure types. Intermediate models (Table S2) found the significant relationship with neighbourhood exposure disappeared once all area, individual and time-related controls were added, and the relationship with visit frequency also disappeared once the other components of SWB were added. Replicating earlier work, however, there were significant relationships between life satisfaction and area level deprivation, age, gender, ethnicity, socio-economic status, employment status, disability status, and marital status.

Finally, and also contrary to hypotheses, the lack of association between a specific visit to the natural environment and negative experiential wellbeing remained in the fully adjusted model; all relationships with other nature exposures were rendered non-significant after adjustment. Intermediate models (Table S5) suggested these effects all disappeared when the area, individual and time-related controls were added, rather than when the other components of SWB were added. Again, like life satisfaction, this suggests that anxiety yesterday was related to factors other than exposure to nature *per se* (e.g. age, ethnicity, employment status and disability status).

#### *Comparison of associations with wellbeing*

How meaningful were the relationships between visit frequency and eudaimonic wellbeing, and the specific visit and positive experiential wellbeing? One way to assess this is to compare the size of the effects with those found for some of the control variables also related to these outcomes in the fully adjusted models, e.g. health and marital status (Tables S2-5). A summary of illustrative comparisons is presented in Figure 1. On the left are the Odds ratios (and 95% confidence intervals) for reporting high levels of evaluative, eudaimonic and positive experiential wellbeing, as a function of: a) having no mobility/work limiting health condition ('good health') vs. having such a condition ('illness/disability'); and b) living with a partner ('married/cohabit') vs. living alone ('single/divorced/widowed').

*Figure 1: Associations between selected socio-demographics and three types of exposure to natural environments and high levels of evaluative (satisfaction), eudaimonic (worthwhile) and positive experiential (happiness) wellbeing (Odds ratios and 95 CIs).*



Note: All coefficients adjusted for area level, individual level and time-related covariates and all other measures of wellbeing.

Replicating earlier work, being healthy and living with a partner is associated with significantly higher odds of reporting high levels of life satisfaction, and indeed happiness yesterday, even after all other factors, including the other three components of SWB, have been controlled. Of potential interest more generally, Figure 1 suggests that while living with (vs. without) a partner is related to higher Odds of reporting eudaimonic wellbeing, this was not found for those without vs. with a mobility/work limiting illness/disability. In other words, seeing one's life as worthwhile was not affected by health related limitations.

Of more direct relevance to the current research, visiting natural environments just 'once a week' (compared to 'never') was associated with similar odds (1.33) of reporting high levels of eudaimonic wellbeing as living with vs. without a partner (1.32), and higher odds than reporting good vs. poor health (1.06). Visiting more frequently (e.g. daily) was associated with even higher Odds (Table 3). Furthermore, although having good (vs. poor) health and living with (vs. without) a partner were both associated with significantly higher Odds of reporting positive experiential wellbeing yesterday (1.21, 1.16 respectively), the impact of visiting nature yesterday (1.66) was at least as important as these two demographic characteristics.

## Discussion

As far as we are aware the current research, using a representative sample of the English urban/peri-urban population, is the first to simultaneously explore the relationships between three types of exposure to natural environments, and the four components of SWB recommended for routine collection by national and international bodies (ONS, 2011; OECD, 2013). Replicating previous findings, visiting nature yesterday was associated with a higher likelihood of reporting high levels of positive experiential wellbeing (happiness) yesterday (McKerron & Mourato, 2013; White & Dolan, 2009). Furthermore, there was novel evidence of an exposure-response relationship between visit frequency and eudaimonic wellbeing. As

the frequency of visits increased, so perceptions of one's life being worthwhile, in terms of the behaviours/activities engaged in, also increased.

Comparing the magnitude of the relationship between eudaimonic wellbeing and visit frequency alongside other correlates such as health and marital status was informative. Supporting previous claims, the activities people engaged in, in this case visiting natural environments, may be at least as important as some life circumstances (e.g. Lyubomirsky, Sheldon, & Schkade, 2005). Further, with respect to (re)connecting with nature, it does not appear necessary to visit distant wildernesses for prolonged periods. Previous analysis of a different aspect of the MENE dataset found that 'town parks' were by far the most frequent location for 'nature visits' among participants, and that over 70% of visits were within 5 miles of the individual's home (White, Pahl, Ashbullby, Herbert & Depledge, 2013).

Although offering unique insights, we also recognise several limitations in the current work. For instance, contrary to previous research among a similar population, living in greener neighbourhoods (White et al., 2013b) or near the coast (Brereton, Clinch & Ferreira, 2008), was not associated with higher levels of life satisfaction. One difference was the use of cross-sectional data here but longitudinal data in some earlier studies. This allowed previous research to control for time-invariant individual level heterogeneity, which tends to provide more sensitive estimates (Ferrer-i-Carbonell, & Frijters, 2004). The cross-sectional nature of the data also limits our ability to make causal attributions. Although, for instance, there is considerable experimental evidence that specific exposures to natural environments are associated with improvements in positive mood (McMahan & Estes, 2015), we cannot rule out the possibility here, even though we controlled for other facets of SWB, that people who visited nature yesterday were already happier, than non-visitors, before their visit.

Intriguingly, that only *happiness* yesterday, but not *anxiety*, was related to a specific visit in the fully-adjusted models, is consistent with McMahan & Estes' (2015) meta-analysis which found that nature exposure has a stronger impact on positive than negative emotions.

A further limitation was our inability to explore the type or quality of the natural environments people visited regularly or yesterday (cf. Giles-Corti, Broomhall, Knuiman, et al., 2005). We are aware that self-reported quality data is starting to be collected in the MENE survey but this has not yet been released. Future studies may thus be able to enrich the current picture by investigating whether visits to better “quality” locations, e.g. those with higher perceived biodiversity or less litter, are associated with higher wellbeing. We also recognise that there was some discrepancy between the time at which the area level (i.e. 2004) and SWB (i.e. 2012-2015) data was collected. This is a common problem when merging multiple datasets, and although the deprivation rank order of LSOAs tends to stay relatively constant we appreciate the potential for error in our estimates caused by changes in greenspace coverage or deprivation status during this ten-year gap.

We also acknowledge that the MENE survey uses self-reported data, and that responses are given to an interviewer present in an individual’s home, which might induce bias or misremembering (ONS, 2013). For instance, although there is evidence that people are able to accurately recall emotional states as long as they pertain to events within the last 24 hours (which is why the ONS questions only ask about emotions yesterday, e.g. Dockray, Grant, Stone, et al., 2010), we know of no work concerning the accuracy of whether or not people accurately recall visiting nature yesterday or over the last 12 months. ‘Ground-truthing’ work is thus necessary to establish the validity of these self-reports in future work. In sum, due to all of the potential limitations above, the precise estimates in the current analyses, and the direction of associations, should be considered with caution.

To conclude, policy makers in many countries are increasingly recognising the potential influence that natural environments have on SWB. In the context of increasing global urbanisation, maintaining contact with the *“working landscapes... that we have inherited from previous generations”* (Obama, 2010) may be important for supporting the subjective

wellbeing of urban and peri-urban residents in particular. The current work suggests that even visiting a natural environment as little as once a week may be at least as important for eudaimonic wellbeing as some socio-demographic factors. This supports both the general contention that the activities we choose to engage in may be just as important as our circumstances in life; and that supporting opportunities for urban populations to (re)connect with nature can play a key role in maintaining their wellbeing.

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